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FUNCTION AND DESIGN[1]

AMONG natural sciences physiology takes a place which in one respect is different from that taken by any other. It studies the phenomena of life, but more particularly the ways in which these phenomena are related to the maintenance of life. Anatomy and morphology are concerned with the forms of living organisms and their structure; biological chemistry, as distinct from physiology, with the composition of the material in which the phenomena of life are exhibited. The province of physiology, in studying the functions of these forms and of this material, is to ascertain the contributions that they make to the organization of the living mechanism, and learn how they minister to the maintenance of its life. Function implies ministration, structure for physiology implies adaptation to function, what in a word may be termed design.

Ultimate analysis of the phenomena with which physiology deals leads to the fundamental distinction between matter in which life is manifested and matter in which it is not. Life is exhibited only in aqueous systems, containing unstable, perishable combinations of carbon with hydrogen, nitrogen, sulphur, phosphorus and oxygen, in the presence of certain inorganic ions, those which are present in the sea, the native environment originally of all forms of life; and the inalienable property that such matter exhibits when alive, and that matter which is not alive does not, is that these unstable organic combinations are forever reforming themselves out of simpler combinations that do not exhibit this property, and do so at a rate which averages at least not less than that at which they break down. This power of self-reformation, spontaneous regeneration, operates not only when living organisms, cells or communities of cells are growing or reproducing their kind; the very maintenance of living existence requires by definition that it should persist. In the absence of water the living process may sometimes apparently be suspended for a time, as it may be if the surrounding watery medium is immobilized by cold; it is a question whether this is anything more than a retardation to a rate of change that is imperceptible by the ordinary methods of observation, and a question how long such suspended animation is possible where it is possible at all. It is only where water has the kinetic activity of the liquid state that spontaneous regeneration of

[1] Address by the president of Section I—physiology—of the British Association for the Advancement of Science, Oxford, August, 1926.

living matter can in general proceed, and then it must, for when it ceases the unstable material ceases to live.

Chemical analogies for this power of spontaneous regeneration, if such exist, can only exist in part; in the present state of our comprehension of it, certainly, it is hazardous to try to trace them. The attempt so commonly made to trace one between the growth of living matter and the growth of crystals in a saturated solution, it is safe to say, is in so many respects on the wrong lines that it is merely misleading. Crystals are not alive. The molecules that constitute the crystal are set in solid formation; so long as the crystal exists they are stable and unchangeable. These molecules collect on the growing crystal, but they exist ready-made in the surrounding solution; they do not come into being by the influence of the crystal; they are themselves so constituted as to take up a set position in relation to each other and to those already ranged side by side in the crystal, as soldiers on the drilling-ground at the word "fall in"; they are available because the solution is kept saturated by the dissolving of smaller but similar crystals that for physical reasons are more soluble in the solution than the larger ones. In contradistinction to this, the molecules that enter into the composition of living matter exhibit the phenomena of life only when permeated with water molecules exercising the kinetic activity of the liquid state; they are unstable and perishable; the added molecules, some of which even during growth and all of them at other times serve but to replace those that perish, do not exist ready-made; they come into being only in conformity to the pattern and under the influence of those already in existence, a pattern that these alone can use; and they are formed out of material that is chemically different from them.

Let us for a moment consider what this spontaneous regeneration implies. Of the various chemical components of protoplasm proteins are generally considered the most important, often the only important, ones. The elucidation of the chemical principles upon which the structure of proteins rests, which took place about the beginning of this century, was, like the neurone hypothesis of the structure of the nervous system, an advance the magnitude of which only those perhaps can appreciate who began the study of physiology well back in an earlier one. For a time it seemed in each case that the problem was solved and all that was to follow was simple. Those were great days. The best-known varieties of proteins, when detached and uprooted from the place where they grew, consist of chains of about a hundred, sometimes nearly two hundred, links. Each link is an amino acid coupled by its acid group to the amino group of one neighbor and by its amino group to the acid group of its other neighbor, a molecule of water being lost at each linkage. There are not more than about twenty different amino acids, so that some of them must occur several times in the chain; in some kinds of protein one amino acid may occupy thirty or forty of the hundred places in the chain. In any such isolated protein it is probable that the order as well as the proportion in which each amino acid occurs in the molecule is fixed, and it is this specific order and proportion that accounts for the specific character and properties of the protein. What could be simpler? And only yesterday all was so obscure.

It is not recorded that in the rush of this advance any one stopped to reflect what number of formations such a protein might still possibly have. Supposing it were a chain of only fifty links, a very simple case; if all the links were different the number of possible permutations is denoted by the innocent-looking symbol $\underline{|50}$. If, instead of all being different, one kind of link recurred ten times, the number would be reduced to $\underline{|50}/\underline{|10}$. If, in addition, there were four that recurred four times and ten that recurred twice, it would be further reduced to

$$\underline{|50}/\underline{|10} \times (\underline{|4})^4 \times (\underline{|2})^{10}.$$

It would now consist of a chain of only fifty links, of which there were only nineteen different kinds, and the number of different arrangements of its parts would be about 10^{48}. Astronomy deals with big figures. Light, it is said, takes 300,000 years to travel from one end of the Milky Way to the other; this distance expressed in Ångstrom units, 10,000,000 of which go to a millimeter, would be less than 10^{32}. So far are we from knowing the structure of protein molecules. So far are we from knowing what variations in disposition of the parts in such a molecule may not occur without our being within a measurable distance of detecting them. For if the number of possible varieties of a protein whose molecular weight is known, and known to be exceptionally small, and which contains the several amino acids in a known proportion, is as great as this, the number that is possible when that proportion may be changed is practically incalculable, each change in proportion being capable of a number of new arrangements that could be calculated, as was done for our hypothetical case.

But in the living cell where these chains are put together each link must first be fashioned and then forged into the chain; unfinished chains *in statu nascendi* must exist which our analytical methods can never detect. In such unfinished chains the order presumably in which the amino acids are linked up is observed, but the proportion must be different from

that in the finished product; for in a chain of nearly a hundred links a particular amino acid, cystine, for instance, may occur only once.

Now it is possible that the analogy of crystal formation may be applied to the reproduction of the characteristic order in which the linkings occur, and that the parts out of which a new chain is to be formed may be collected and brought into position alongside of the corresponding parts of an existing chain by forces that are similar to those that determine the latticed relations of atoms in a crystal. But something more than this is required to account for the linking up of these links by the loss of water, and still more for the fashioning of the links themselves. In plants all varieties of amino acids come into being as required; in animals, it is true, some must be supplied ready-made in the medium in which the proteins grow; but even in animals some of them can be formed from material of a totally different nature.

Wherever this is the case we have to suppose that it is by selective emphasis of certain otherwise unemphasized but possible arrangements of atoms or groups of atoms, evidence for the occurrence of which under similar conditions in the absence of life is generally not obtainable. Specific catalyzed syntheses must cooperate with the forces that merely sort out and place in proper order the assembled parts, and must fashion for them the particular links that they need at each step. Specific catalytic agents playing an important part in cell chemistry are familiar in the enzymes found in digestive secretions and also locked away within the cells themselves. There is much to support the idea that such agents act by modifying the chaotic, indeterminate, kinetic agitation of certain kinds of molecules in their immediate neighborhood in such a way that the relative positions in space of groups capable of reacting with one another tend to become those in which reaction is likely to occur and to occur in conformity with a certain pattern. The peculiar thing about the chemistry of living matter is not that the reactions that are characteristic in it are novel, but that in the rough and tumble of ordinary liquid systems their occurrence is almost infinitely improbable. Where there is life circumstances exist which make them the rule. Any one conversant with work in animal metabolism can supply many illustrations; for instance, it has been shown that in a simple solution of the amino acid alanine traces of methyl glyoxal occur; in the animal body there is reason for thinking the reaction may become practically quantitative. Forces which determine the relative positions of adjacent foreign molecules and so affect their behavior are something to which there is no analogy in the growth of crystals in a saturated solution.

Moreover, if the forces that determine the reproduction of a certain order in the arrangement of the parts of a protein are similar to those that determine the lattice pattern of a crystal, the crystals with which the comparison is made are solid, and life is manifested only in liquid aqueous systems. The analogy should rather be with the formation of liquid crystals, a phenomenon that is itself as yet too unfamiliar to shed common light on the obscurity of spontaneous regeneration. The ordered disposition of the ultimate components of protoplasmic systems is such as to leave play, generally but little checked, for the fluid properties of water, and in some modified degree too of molecules and ions dissolved in water. Even a solid jelly may include within its protein framework a hundred times its weight of water in which diffusion is free to take place almost as if the framework were not there, and protoplasm, with commonly twenty times as much protein in it as this, more often resembles a fluid of varying viscosity than a solid gel, which means that the great protein chains float and drift in the whirlpool of kinetic agitation, observing, it may be, so far as is possible, certain unstable relations to their kind, but with no rigid fixity. It is commonly felt that the behavior of unicellular organisms makes the hypothesis necessary that there is an insoluble surface layer that keeps the watery contents of the cell from dispersing in the water that surrounds it. Much experimentation, and no lack of speculation, has not made clear what the nature and structure of this limiting layer is. It may be that the flexible cohesion at many alternative points between clinging floating chains of amino acids, the innermost of which are made fast to the nucleus, may go some way to maintain the identity of the cell and prevent its contents from scattering.

But in the chemical make-up of protoplasm, proteins, the most abundant component, are not the only ones that are necessary. Preeminent among the others are the nucleic acids. When we consider what has been learned of the behavior and of the chemical composition of the nuclear chromosomes, and that according to Steudel's reckoning the nucleic acids form 40 per cent. of the solid components of these chromosomes, into which are packed from the beginning all that preordains, if not our fate and fortunes, at least our bodily characteristics down to the color of our eyelashes, it becomes a question whether the virtues of nucleic acids may not rival those of amino acid chains in their vital importance. From Steudel's figures it can be reckoned that there are about half a million molecules of nucleic acid in a single sperm cell of the species with which he was working.

But in addition to nucleic acids there are also strange compounds of higher fatty acids containing

suspiciously significant groups, identical in their general character with those found also in nucleic acid, namely, phosphoric acid, organic bases and sugar; and besides these there are the mysterious sterols. All of these are frankly insoluble in water, and yet have in some part of their composition features that make them not indifferent to water or even to the molecules and ions that exist in true solution, in the liquid state, within the cell. The physical condition of these insoluble substances in the aqueous system of the cell is still little understood. All that can be said with certainty is that they must modify its homogeneity even more than the long floating chains of amino acids, however much these may be linked together one with another. If the characteristic behavior of living matter is rightly regarded as due to the order that it introduces into the movements and spatial relationships of foreign molecules in its vicinity, then these insoluble components may well be expected to play a leading rôle by forming films and surfaces that permeate its texture and delimit its parts.

Such an analysis of the chemical meaning of material life viewed in the light of scientific facts has to be largely an exercise of the imagination, but it may present itself as an intellectual necessity. If it is right to regard the power of spontaneous self-regeneration as the distinctive property of living matter, it is not intellectually possible to be content with a phrase and dismiss it. A phrase is itself an image, and an image, however shadowy, has parts and dimensions. Those who feel it an intellectual necessity to explore unexplored lands can not procure maps, but that does not justify their setting out with no forethought or reasoned plans.

The beginning of life, if it is an intellectual necessity to trace this, would thus appear to have been in the coming together of atoms of certain elements in such a pattern that this power in its simplest form resulted from its design. Some might call this event fortuitous, others the predictable outcome of the inherent properties of those elements, the inevitable operation in the course of time of the laws of chance. Those who call it fortuitous may go so far as to regard the whole history of life as fortuitous, and give priority to the concurrence of the atoms over the properties and functions that are revealed by the concurrence. The others may look on life as the fulfilment of the destiny of these elements, and give priority to the potential properties of matter over the concurrence which was no more than their epiphany.

If this analysis is approved and the distinctive property of living matter, the power of self-regeneration, depends upon the power of limiting the movements and directing and controlling the spatial relations of surrounding molecules so as to modify their chemical behavior, it is the exercise of this same power that leads to the formation of substances such as starch, glycogen and fats; and in so far as such substances contribute to the regeneration of the living matter, the power of forming them contributes to its survival. Where energy is necessary for such synthetic rearrangements of adjacent matter—where, that is, the rearrangement involves coercion of atoms into positions of strain in which they have the potential energy of position which we call chemical energy—this energy may be derived from the radiant energy of the sun or from the combination of oxygen with adjacent organic matter. In the latter case the combination is again a manifestation of the power of ordering the disposition of surrounding molecules and directing their movements so that they behave as in other circumstances they would be but little prone to do. The energy so liberated, besides contributing to the formation of new living matter or of the material to be used in its formation, may serve in other ways to promote the processes by which life is maintained. It may accelerate them by imparting increased kinetic activity or rise of temperature, or may bring about movements that are resisted by external forces, and so enable the living system to do work.

This is all merely a restatement of the commonplaces of biology, necessary only as part of the attempt to correlate them physiologically with the fundamental property of that which is alive to regenerate itself at the expense of material that is not alive. This faculty implies the power of introducing order into the chaotic movements of adjacent matter in conformity with patterns that it possesses. It is a faculty resident in material that is capable of incalculable variation. The number of permutations of its parts that are possible without affecting the results of such analysis as is practicable defies calculation. Their calculation, were it possible, would lead to figures that are so large as to mean no more than the dimensions of the universe. Some of these permutations confer synthetic powers which others do not. When they appear, are they not what biologists call for short mutations? But when they appear, if they retain the power of self-regeneration, and if they minister to its maintenance, they will *ipso facto* survive. For whatever promotes persistence of this power must itself survive.

A disposition of matter in molecules or aggregates, unstable and incalculably variable, that has and retains the power of determining the disposition of matter not yet so disposed in such a way as to conform to its own disposition or to patterns which help it to exercise this power, is all that must be premised

for the whole of evolution to follow. Variations that do not or cease to contribute to the retention of this power do not survive. The condition of survival is ministration to self-regeneration, that is to the maintenance of life.

Before the days of vertebrates, in pre-Silurian time, an unstable variation in the disposition of atoms and organic combinations of atoms occurred in certain types that was mainly protein in character, a protein to the making of which little short of 200 amino acid links must contribute. Coupled to this protein, which probably is not the same in all species of animals in which it is found, is another group containing iron that is probably always the same. This group is of remarkable nature, and is closely related to one that occurs in the far older substance chlorophyll. This complex substance hemoglobin had the power of attaching to itself two atoms of oxygen for each atom of iron that it contained in such a way that it could be readily detached and made available for effecting oxidations. Such was the service that this variation rendered that it is safe to say that without it there could be no vertebrate creation. It is this service that has made it possible for it to survive to this day, when in the human species alone it is being produced at the rate of about 10,000 tons a day. The story of the service of chlorophyll would, of course, be more remarkable than this.

Natural selection applies to the survival of the chemical forms of living matter as it does to complex living organisms. These forms, infinitely protean in their variety, survive and persist in so far and so long as they minister to its self-regeneration. It is the principle of survival by service. Function alone gives permanence to structure. Structure without design is a pathological excrescence that has in itself the seeds of its own destruction. What does not minister to self-regeneration has no enduring share in life, for self-regeneration is the key to life.

Why is it that what may be termed official physiology takes so little cognizance of the doctrine of evolution? These branches of biological study appear to follow courses so exactly parallel that they never meet.

The doctrine of evolution digs down into the foundations of scientific philosophy. If a physiologist addressing physiologists ventures to say anything on this subject of supreme appeal to all biologists it must be in exaltation of the work of those who have approached it from the morphological side, and it may be in hopeful anticipation of the ultimate share in the elucidation of some of its problems to be borne by physiology.

On the part that function plays in the determination of structure it is to be supposed that physiology will ultimately, at any rate, have something more to say. May I submit to the consideration of physiologists certain points in the physiological development of the machinery of the body where, unless I am mistaken, it is possible to detect the operation of function in determining the design of the machine? The properties and behavior of cells result from the properties and behavior of the material composing them. When a muscle cell contracts this is, in general terms, a reversible rearrangement of its parts in response to some alteration in the distribution of forces within or about it due to a disturbance from without. Such reversible reaction to adequate disturbance is a property common in the material of which living cells are composed. In addition to this reversible type of reaction there are irreversible reactions which are characteristic of other kinds of cells, and it is what we call connective-tissue cells that I would ask you to consider. There are several kinds of connective-tissue cells, but they are alike in that they produce and discharge into their vicinity material of a characteristic composition; in some of the commonest this material is chemically collagen, the substance out of which gelatine can be obtained. In course of time these cells come to be embedded in the material which they deposit about themselves and so form one kind of connective tissue. Cells capable of behaving in this way are found, however, which have not yet exercised their faculty; these fibroblasts are then undifferentiated wandering cells that have found no abiding place in the community in which they have their birth. What it is that makes them settle down and start producing the material in which they come to be imbedded has never yet been determined. But the most striking structures to which they give rise are the tendons and aponeuroses that make the muscles fast to the bones, and the ligaments that bind the bones to one another. The material that they deposit is composed of inextensible fibers that lie in the case of tendons, at any rate so exactly and exclusively in the line of the resultant of the tension set up in the muscle to which they attach themselves, that it is difficult to believe that the disturbance which starts them producing their characteristic secretion is anything else than the pull exerted on them by the muscle fibers to which they are attached; the recurring external disturbances that produce reversible states of tension in the muscle, indirectly producing in them an irreversible reaction, which consists in the discharge of material that by its inextensibility can transmit the tension along the line of the force that provokes its deposition. In their simplest form cells of this kind deposit the wavy fibers in areolar tissue which, when straightened out under the action of a displacing force, set a limit by their inextensibility to the dislocation of the part first

affected, and so distribute the action of the displacing force over surrounding areas. It is interesting to note that the origin of cells of this kind has been traced to the mesothelium cells that line tissue spaces and serous cavities, the clefts that make the gliding displacements of parts over one another possible. The deposition of fibrous material seems here, as in the tendons and ligaments, to be the result of reaction to the recurring disturbances set up by displacements, such, for instance, as those of the lungs, the alimentary tract, the heart and pulsating vessels, and the deposition occurs in the line of strains set up by the displacing forces. The service rendered by this behavior of the cells is that the fibers which they deposit, in virtue of their inextensibility, limit the extent of displacement at any one point by distributing it to surrounding parts.

The other component of areolar tissue, the elastic fibers, is similarly produced by other cells. These fibers take a straight course between their attachments; displacements in the line of their deposition are rendered possible by their stretching, and are recovered from by their elasticity.

The contribution made by such cells to the fabric of the body appears to result from the recurring operation of disturbances, to which they react by depositing fibers along the lines of disturbance.

More striking are the properties of cells upon which the formation of the skeleton depends. The cells that make bone not only secrete fibrous collagen, they also encrust the fibers with insoluble lime salts, and it has long been subject of comment that the rigid bone that results always comes to lie in the line of prevailing strains and stresses. The analysis of the structure, for instance, of the head and neck of the human femur, by Wolff and others who have followed him, shows how strictly this is true. Calculations prove that no particle of bone lies anywhere but where the strains dictate. We can predict with certainty, it seems, that it will be found that bone cells are composed of material that in reacting to physical forces directs, in constant relation to the line of action of those forces, the deposition of the substances which make up this connective tissue. Bone can only arise where strains and stresses set up this reaction, and the greater the strain or stress the denser the deposit. When a bone is fractured many bone cells are dislodged, and in the abundance of nutriment that ruptured vessels supply, these cells, released from their imprisonment, multiply. At first the force of gravity and the twitching of muscles acting on the soft semifluid tissues between the broken ends of the bone supply stimuli that are indeterminate in direction, and such reaction as occurs results only in the formation of loosely ordered calcareous fibers; but even this soft callus gives some degree of rigidity, sufficient to restrict the strains gradually to more and more clearly defined lines along which in proportion a stronger reaction can take place. Once it is established that bone corpuscles react to strain and stress by discharging collagen, the intimate spatial disposition of which, as well as of the lime salts with which it comes to be encrusted, is determined by the directing forces to which it is exposed; and once it is recognized that the law of spontaneous regeneration requires that this reaction will persist in proportion to the prevalence of these forces, not only must the gradual replacement of callus by appropriate permanent bone necessarily follow, bone in which no particle persists except it be in the line of constantly recurring stress and strain, but it will also necessarily follow that the position of every spicule of bone in the skeleton, cancellous or compact, is the expression of a physiological reaction to the forces of gravity and muscular tension. The evolution of the machinery of the connective tissues seems to be not entirely the result of natural selection and the survival of individuals in which this machinery chanced to be of appropriate design. The appearance in early vertebrates of the material that is characteristic of the bone corpuscle seems to have ensured that skeletons would take a shape determined by the direction of the forces to which these corpuscles were exposed, and that the formation of this skeleton is as much a reaction to recurring stimuli as are the reflexes, composite movements and postures characteristic for the species.

This conception of the way in which the vertebrate connective tissues take their shape transfers a large share of the development of the bodily form back into the nervous system, in which the machinery is stored that directs and determines the habitual movements and postures that in reaction to external disturbances are specific. A physiological account of the evolution of the nervous system, one certainly that is based on the chemical constitution and chemical behavior of its component parts, must seem almost infinitely remote from practical investigation. But the work of Pavlov has made one thing clear, that by a physiological reaction in it machinery may come into existence which did not exist before. The repeated occurrence of a disturbance at times that are uniformly related to the normal operation of existing machinery results in the acquirement of a new reaction which must require machinery that is new. It is rendered probable, if not proved, that this new machinery is situated in what may be called the growing point of the central nervous system, the cortex of the cerebral hemispheres, the part where all is not cut and dry, where cells retain more of the properties of the developing neuroblasts, the properties that enable

them to grow out through the embryonic tissues along courses that make it certain that the maturing organism will behave in a manner true to type. In the formation of a conditioned reflex two events are made to occur in the cerebral cortex at times which are uniformly related to one another; one of these events, from the constitution of the nervous system, necessarily results in a certain activity of some muscle or gland, the other has been hitherto in no way related to such a result; after many repetitions of the association of these events it is found that that one which previously had never resulted in this particular activity comes to have this result as certainly as the other.

The sight and smell of food in any hungry animal results in the secretion of saliva because the cells to which the effect of these visual and olfactory stimuli is referred are anatomically connected with cells that set the salivary gland in action; the cells on which some particular sound takes effect are not anatomically connected with them, and this particular sound has therefore no effect upon them. But with the establishment of the conditioned reflex the anatomical connection comes into existence. As a result of a functional reaction of nerve cells to disturbances in other nerve cells with which they were not previously anatomically connected, a structure appears which is indistinguishable so long as it lasts from the structures that constitute any other reflex arc. The conditions that determine its persistence or effacement have been, and are being, studied as thoroughly as were those which allow it to appear. The outcome of these studies must be of incalculable importance in evolutional physiology. They are being watched with the keenest interest doubtless by all biologists, but more especially by those who believe that physiology has to take a much bigger part in the solution of some of the fundamental difficulties of biological science than it has been able to take in the past.

But if and when it is possible to trace the origin of structures to functional reactions of cells, and to reactions that depend upon the chemical properties of the cell substance; and if and when this is possible not only in the connective tissues, but also in the nervous system, the functions of which have so controlling an influence on the operation of every part of the body; until it becomes clear that the results of changes in such influence reappear in succeeding generations, the study of functions can have no bearing upon the ultimate problem of biology, the evolutional history of life upon the earth. Pavlov communicated to the last International Congress of Physiology in 1923 some results of experiments that he had done upon this subject which, when confirmed, would electrify the atmosphere. Conditioned reflexes that are established only after many—eighty or a hundred—repetitions of the associated stimulus, in each succeeding generation require fewer and fewer repetitions, and in the fourth may be established after only four. In April of this year he wrote to say that owing to other work he had not been able to give the necessary time to confirmation of these results. We are content to wait.

In the great question whether characteristics developed in the life of an individual have any influence on descendants, experimental evidence must come slowly. In what is called parallel induction a step has been taken which is probably of greater importance than is generally conceded. External influences that affect the bodily characteristics of an organism affect also the germplasm in such a way that these characteristics appear in the first, and even, in a less degree, in the second generation, born after the external influences have ceased to operate. While such experiments furnish evidence only of a temporary change in the properties of the germplasm, one that may be put down to the lodgment in it of unassimilated foreign matter that is gradually eliminated, the fact that the eternal germplasm has been shown to be subjected to temporal influences must not be belittled. A true mutation is not eternal. Our descendants may be able to dispense with hæmoglobin. Whether the hereditary melanism that in certain moths, it is said, can be induced by food infected with manganese, is something more than such parallel induction, I hope there may be some present who can say.

Physiological inquiry is a stream that has many sources; its waters gather from quarters far removed from one another. A marvelous meeting took place in the early years of this century when the forgotten experiments of Mendel came to the surface again, and found corroboration in the cytological studies that from about the same time had pursued their slow obstructed way above ground in the endeavor to elucidate the changes in the nucleus of maturing germ cells. In a resting germ cell the chromosomes form an even number, characteristic for the species; they consist of half that number of pairs of homologues, one of each pair descended from the paternal element in the last zygosis, the other from the maternal. At one of the cell divisions by which the germ cell gives rise to the mature gamete, with half the characteristic number of chromosomes, there occurs a segregation of the two members of each pair so that they pass into different gametes; the exact cytological equivalent of Mendelian segregation of allemorphic pairs of characters. To-day the study of genetics and of the "topographical anatomy of the chromosomes," with its "groupings" and "crossings over," seems to

call out for chemical assistance. It may be that in the lifetime of some of us those confluent streams of thought and experiment are to be joined by yet another that rises in the vast, remote and, as it must appear to some, muddy swamps of physiological chemistry; and it then, forgetting its "foiled, circuitous wanderings," will form with them a "majestic river, brimming and bright and large."

J. B. LEATHES

THE RELATION OF EVOLUTION TO MEDICINE[1]

NOT so very long ago the phrase "art of healing" covered quite satisfactorily nearly every activity of the medical profession. To-day the term "scientific medicine" seems to have displaced the older phrase—but not actually, for while recent advances in medicine can definitely be laid to the development of scientific methods of investigation and to our increasing familiarity with fundamental facts concerning organic life, the *art* of medicine still relates to the skill with which our newly acquired knowledge is applied in the fields of medicine and surgery. Medical science, therefore, pertains more specifically to our efforts toward acquiring a better understanding of biological laws which may serve as a basis for originating newer and improved methods of curing and of preventing human ailments and diseases. In other words, it constitutes the foundation upon which the practice of medicine is being remodelled along more substantial and scientific lines.

This recent development has brought within the range of medical research certain branches of biological science whose relevant value has heretofore been rather obscure, if recognized at all.

While the practice of medicine is primarily concerned with that which lies beyond the range of normal variation, our ability to analyze any abnormality is directly proportional with our knowledge of what constitutes normal conditions and the normal range of variation. In the past, the treatment of an abnormality has consisted, figuratively, of an attempt to directly force it back within the normal; modern medicine, however, tries rather to preserve normal conditions, or, in the presence of abnormalities, to eliminate them by reinforcing those factors which ordinarily safeguard the body against them. Hence the very basis of our future progress may be said to depend upon our knowledge of what constitutes normal conditions and of the biological factors which ordinarily maintain them, quite as much as upon our familiarity with those factors which are capable of disturbing that state of normalcy.

[1] From the Department of Surgery, Yale University, New Haven, Conn.

Health, and disease or abnormality of any sort, are merely interactions between the human organism and its environment; health constitutes the normal phase, the others result from the introduction of some element of disturbance.

In the study of human ailments and disorders, we must realize that man is *not* a specially created being placed here to dominate over all the previous inhabitants of this globe; physically, he is merely one of a countless number of similarly constructed, highly complex organisms. So completely does he duplicate in his physical being the vital organs, the various distinctive tissues and an almost uniform homology of the skeletal segments of other creatures that the physical modifications by which he is distinguished from them seem very superficial. All his physiological processes and specific structures carry so far back into the remote past that, in comparison, man's stature and body-form would seem to be a very superficial source of differentiation and a very modern acquisition, while his mental superiority would seem to be an endowment of only yesterday.

What is the relationship of evolution to medicine? The problem of evolution permeates every fundamental branch of medical education in such a manner as to signify that it represents a most important and unexplored source of biological knowledge which should prove of inestimable value to future medicine.

After the anatomist has familiarized himself with the structures of the modern human body, he immediately finds himself plunged into the problem of evolution. Why? Because in his search for advanced knowledge he must naturally turn his attention toward their original source and attempt to learn the history of their development.

The various branches of biology consider the phenomena of life as displayed by all types of living organisms, ranging from the tiniest single-celled protozoa to the largest and most highly organized forms, including man. In those studies a classification of these forms of life according to their grades of organization and according to phylogenetic strains disclose their evolutionary relationships in a striking manner.

Embryology explains to us the modern development of the highly complex individual from a single-cell stage. It has bared to us many secrets regarding the evolution of mankind. But the present embryological process is, of itself, a product of evolution, having become more intricate as each higher level of organization was attained by the matured creature. Thus while the prenatal process serves primarily for the creation of a new individual, it still retains phenomena which bind man inseparably with the lower forms of life—a fact which is more clearly demonstrated in comparative embryological studies.

There is one branch of biological science, however, which unfortunately has hardly as yet been mentioned in the same breath with the word "evolution." I refer to physiology, and I use the word "unfortunately" because I feel convinced, as a result of my own studies, that the greatest strides in our knowledge of organic evolution, and especially in its usefulness to medicine, will follow the time when the problem of evolution is investigated on a basis of physiology at least equal with that of morphology.

Organic life implies organic activity, and this activity, in turn, implies function. Function is the interaction between an organism, or a part of an organism, and its immediate environment. Change in the organism or in the environment inevitably imposes some difference within the usual scope of that interactivity. Hence, physiology as a study of various organic interactions (either physical or biochemical) started at practically as simple a beginning as did organic morphology. Consequently, since every important physical change must have been associated with a corresponding physiological one, the evolution of organic interactions must form no less important a part in our problem than the various alterations of structure.

The strong condemnation of Lamarckianism has, undoubtedly, operated to discourage much effort in this line, so that scientific attention has been centered upon the morphological side as a source of more positive and accurate information. But in view of our recent advances in biological knowledge it would seem as though conditions were now suitable for a serious attempt to investigate this less tangible, but none the less actual, physiological phase of the problem.

Although the factors by whose action all the modern forms of life have become evolved display themselves in such a wide range of scientific study, our common perception of the phenomenon of evolution is far from perfect. Biology gives a fair representation of the process, but dealing as it does with the final products of evolution, its nature is that of a modern cross-section of organic life, and the representation is without actual depth. Embryology supplies some depth to the picture, but in a hazy and incomplete manner, since it can only reflect, briefly, certain high spots in the course of evolutionary chance—a process which extended over hundreds of millions of years. It is only by enlisting the aid of geology, paleontology and their allied sciences that we may hope to gain a true perspective of the phenomenon of evolution.

Since the medical profession is primarily concerned with the human species, our interest would naturally be focused upon that part of the problem which relates to man. Hence it is with no great surprise that we learn that one of our leading medical institutions has definitely established a department for such study, under the title of physical anthropology. This appears to be a real progressive step which invites the attention and similar action of all our other important institutions of medical learning and research. It is only a question of time when the practical value of a clear insight into the evolutionary development of mankind and his exact relationship to other organic forms will be generally recognized, and especially its benefits to the medical research worker of the future.

I believe that I may state without fear of contradiction from a single one of them that fully one hundred per cent. of all those to whom we owe our important advances in modern medicine are not only fully assured of the *fact* of evolution, but, in addition, that they are strongly convinced that the scope and rate of our future advances bear a direct ratio with our better understanding of the biological laws which have guided the course of evolution. Although the same percentage undoubtedly holds among our research workers, we can hardly claim it as prevailing among our colleagues who are engaged in various lines of clinical practice. Their duty lies in distributing to the public the benefits of our improved methods, and their interests are not so intimately associated with the fundamental facts of biology. Nevertheless, only a small minority of them are so unfamiliar with these facts as not to subscribe to their belief in evolution.

If it were commonly known how thoroughly medical science ratifies the phenomenon of evolution and if the public had a true realization of how intimately this phenomenon is correlated with the present interests and the future progress of medicine, there would surely be far less controversy concerning it among laymen.

Just as the ancient Hebraic laws would be poorly adapted to the legal needs of modern communities, so the biblical account of creation given to a people without scientific training can hardly be expected to satisfy the demands of our present state of common and scientific knowledge. No crime can be attached to our amplifying the worthy traditions of our ancestors, any more than to a modification of their customs and rules of conduct; rather would the wrong-doing lie in a failure on our part to actively seek those benefits for ourselves and our progeny which our higher knowledge is constantly bringing more closely within our reach.

Because the indications point to the probability that many of the greatest benefits to mankind resulting from a better understanding of evolution will be of a physical nature and fall within the jurisdiction of the medical profession, it does not seem unreason-

able that we should be looked to to take a leading part in this work. The particular confidence and regard with which we are held by the public impose a fearless seeking after truth on our part wherever it may result to their advantage; and because of that confidence, probably nothing would do more to convince the people at large of the truth of evolution than an open declaration of some sort by the profession of our acceptance of its principles and of our firm belief in the advantages to be gained by its further study.

DUDLEY J. MORTON
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FIELD TRIPS IN GEOLOGY

A NOTE in SCIENCE for June 18th last, contributed by W. C. Morse under the above caption, reminds the writer of another "traveling field course" which provides a close parallel to the western trip of the Summer School of Geology and Natural Resources conducted by Princeton University during the present season.

Eleven years ago Columbia University offered a summer course in physiographic geology under the direction of the writer and two assistants. The party numbered twenty-eight (or thirty-two, counting those who joined for part time only), and spent two months on a trip to the Pacific Coast. We had a special car part of the time and a suitable equipment, including portable blackboard and wall maps, as well as topographic quadrangles and published reports for areas to be specially studied. Lectures and examinations supplemented and checked the field studies, and full university credit was allowed for work satisfactorily completed. Among the places visited were the Yellowstone National Park, Glacier National Park, the Grand Coulee and the Columbia River Gorge, Lake Chelan, Crater Lake National Park, the Klamath Lake block mountains, the San Francisco earthquake rift, Yosemite National Park, Lassen Peak volcano and the Cinder Cone, Lake Bonneville shorelines and the Wasatch fault north and south of Salt Lake City, the Hagerman Pass region of alpine glaciation, Pike's Peak and the Garden of the Gods, the foothills regions of Morrison Park, Golden and Canyon City, the Rocky Mountain peneplane west of Palmer Lake, the Royal Gorge of the Arkansas River, the Petrified Forest at Adamana, and the Grand Canyon of the Colorado (the last two on a side-trip taken by some members only). Special opportunities for seeing the country were afforded through the hospitality extended by chambers of commerce and other organizations which placed automobiles at the service of the party at a number of points along the route. Still more valuable was the expert guidance enjoyed in the San Francisco region, where we joined a party under the direction of Professor Lawson, in the Lassen Peak district, where Dr. Diller was our host for several days, and in other areas where those best acquainted with the local geological features generously placed their special knowledge at our service.

For a number of years Columbia University has offered each summer several physiographic field excursions, varying from twelve days to three weeks in duration and commonly attended by from twenty to thirty persons.[1] One of these, offered jointly with the University of Wisconsin, usually covers, among other points, the Pike's Peak, Estes Park, Yellowstone Park, and Glacier Park regions; another traverses the Highlands and parts of the Catskill, Adirondack Mountains, White Mountains, and New England coast regions; and a third, introduced more recently, crosses the Atlantic Coastal Plain, Piedmont, Blue Ridge, Great Valley and Folded Appalachians to the Appalachian Plateau region of Virginia and West Virginia. These excursions are in addition to others on which other phases of geology are emphasized, and have been under the direction of Professor A. K. Lobeck (for the first two) and Professor F. J. Wright.

In this connection it may not be out of place to call attention to an experiment in field work for elementary students in geology now being tried at Columbia University, although no claim to novelty is made. Building operations in and about New York City, while involving temporary excavations most useful to students of the local geology, progressively restrict access to many of the exposures formerly utilized for purposes of field instruction. An increasingly larger proportion of the field period must be spent on subway or other transit lines, for classes are forced to go farther and farther afield to make satisfactory observations. The change in this respect since the writer attended field classes in geology at Columbia some twenty-five years ago is very marked, and the task of providing a series of interesting field excursions of proper educational value has become more difficult each year. To meet this situation the department of geology last year offered a three days' excursion by motor bus across the Triassic Lowland of New Jersey with its trap ridges; over the crystalline highlands where the Schooley peneplane finds its typical development; down the Great Valley past the Crystal Cave near Kutztown, the end of the highland

[1] In the summer of 1926 both the number of excursions offered and the number of registrations have for special reasons been temporarily reduced.

prong at Reading, the iron mines of Cornwall, and the type locality of the Harrisburg peneplane; up the Susquehanna through the water gaps into a typical portion of the folded Appalachians; and finally southward past the tip of the Carlisle prong of the Blue Ridge to the Battlefield of Gettysburg, where the influence of topography upon military operations could be studied to unusual advantage. This excursion, covering a week-end in term time, was acceptable as a substitute for the required local field trips; and although the cost was more than thirty dollars per capita, forty-eight men out of a class of sixty elected to take it in the fall semester, fifty-five out of a class of seventy-five in the spring semester. So successful were the results achieved that despite the expense (registration and field expenses make for the course a total fee of $67.50) it has been decided to eliminate the local field trips and to require the New Jersey-Pennsylvania excursion of all college students wishing credit for a laboratory (or field) course in elementary geology.

The problem of handling fifty or more elementary students on a somewhat extended geological field trip, when they have studied the subject but a few weeks, presents special difficulties. A large number of wholly novel conceptions must be presented to the men in a very short space of time. To this end there has been prepared a brochure of some thirty quarto pages, containing:

(1) An explanation of topographic maps, and directions for using sets of these maps, provided for the purpose with route of the excursion marked upon them.
(2) An outline of the major events in the geological history of the northeastern United States.
(3) A brief description of the physiographic provinces crossed by the excursion.
(4) A complete itinerary of the excursion, with discussion of the detailed geological features studied en route.

Block diagrams are much employed to convey most effectively the relation of geological structure to surface form; cross-section diagrams illustrate the physical evolution of the region traversed, while photographs add an interesting element to the presentation. Special stress is laid upon major geological conceptions and principles, rather than upon technical details; for the object of the excursion is not to make a geologist out of the student (that may come later for the exceptional few) but to awaken interest in what for him is a new field of thought, and to start him thinking in new directions and in new dimensions.

A substantial contribution to this end has been secured through the courtesy of Dr. Ashley, state geologist of Pennsylvania, who has each time the party passed through Harrisburg generously taken time to meet the men and discuss with them interesting phases of Pennsylvania geology and geological work in general.

Experience seems to show that for most of the men the interest of the features observed is sufficient to secure a proper attention to the objects of the trip; but additional assurance against any tendency to turn the trip into a "joy ride" is obtained by requiring of each member a detailed written report which must conform to specifications and answer questions set forth in the booklet above mentioned. In grading the reports particular weight is given to individuality and originality of composition and illustration; and an unsatisfactory report means loss of credit for the course, in so far as fulfilling college requirements for a certain number of laboratory (or field) courses is concerned.

It is as yet too early to say how satisfactory will prove the substitution of a long and comparatively expensive field excursion as an absolute requirement in place of shorter and cheaper local trips and indoor laboratory work. It can be said, however, that the interest of the men in the science of geology appears to be greatly increased under the new arrangement; that they learn very much more during the three days spent in seeing geological features developed on a grand scale, in collecting rocks of great variety over a large area, and in making constant practical use of topographic and geologic maps, than they formerly did with six or eight short field trips and as many indoor laboratory exercises on rock specimens and maps; and that the general effect on the elementary teaching in geology has been so good as to justify temporary withdrawal of the local field and laboratory work and the substitution of the three days' excursion as a regular requirement. Whether time and events will justify the procedure remains to be seen.

DOUGLAS JOHNSON
COLUMBIA UNIVERSITY

SCIENTIFIC EVENTS

THE RECENTLY DISCOVERED GIBRALTAR SKULL

AT the Oxford meeting of the British Association the first authoritative account of the discovery by Miss D. A. E. Garrod of a human skull associated with Mousterian implements at the Devil's Tower, Gibraltar, was given in a session of the Anthropological Section.

Miss Garrod, who undertook the excavation of the site at the suggestion of the Abbé Breuil, found that

the cave contained a succession of seven deposits, which emerge from the mouth of the cave and spread fanwise in a succession of steps. All levels of the deposits contained a large number of animal bones, some broken and burned by man, some evidently the relics of an animal's lair. As the cave faces north, it was probably occupied by man in summer only and by animals in the intervals of human occupation. The animal bones included deer, wild goat, boar, and rabbit in abundance, and, rarely, horse and ox. Resting on the raised beach which formed the seventh and lowest deposit was a carpal bone of an elephant. Implements of Mousterian type were found at all levels down to the fifth, those of the second level being definitely assignable to the upper Mousterian; but no implements of a later industry and no pottery were found.

The removal by dynamite of a large block of limestone in the hard travertine of the fourth level opened up a number of fissures and led to the discovery of a human frontal bone at a depth of 15 cm. from the surface of the deposit. The left parietal was discovered half a yard away, but, whereas the frontal bone had been loosened from its matrix, the parietal was firmly embedded in the travertine and had to be brought away in a mass of that material for reduction in the laboratory. As explained by Mr. L. H. Dudley Buxton, to whom that task was entrusted, the freeing of the interior from the mass of deposit with which it was filled proved a particularly difficult and tedious operation. Implements of quartzite and flint definitely of Mousterian type, but less well made than those of the overlying levels, were found near the skull. The fact that the skull and the implements were found embedded in the travertine in a manner allowing no possibility of disturbance places the Mousterian age of the skull beyond question.

The anatomical characters of the skull were described by Mr. L. H. Dudley Buxton. Owing to the fact that the greater part of the month which had elapsed since the skull had been brought to England had been taken up by the task of freeing the fragile bone from the travertine in which it had been embedded, it was possible to put forward tentative conclusions only; but an attempt had been made to reconstruct the upper part of the skull. There is no doubt that the two fragments belong to the same skull. From various characters it would appear to be that of a very young person; but the exact age and the sex are difficult to determine. A comparison with the three skulls of Neanderthal man of immature age available—a skull of a child of five from La Ferrassie, the skeleton of a youth found at Le Moustier, and fragments of the skull of a child, perhaps of eight years of age, from La Quina—shows that it agrees with them in the characters in which they differ from those of modern skulls of corresponding age. The measurements, which, however, must at present be regarded as entirely provisional, indicate that the skull is broader in its proportions than would have been expected, nor are the eyebrow ridges and temporal fossæ developed in the manner distinctive of Neanderthal man. The most striking feature in the parietal bone is the fact that the parieto-squamous suture, which is more or less straight in the apes and the human infant and bowed in the adult man, in the Devil's Tower skull is most markedly bowed; but instead of a regular squamous suture, with a bevelled edge, the actual edge of the bone is only recessed very slightly—a condition which is to be attributed to age and not to race. On the provisional measurements which have been made the cranial index works out at 80, a high figure which further consideration may make it necessary to correct.

THE CELEBRATION OF THE TERCENTENARY OF FRANCIS BACON

THE Tercentenary of Francis Bacon was celebrated at the University of Cambridge on October 5, when, at a special congregation, the chancellor of the university (the Earl of Balfour) conferred the degree of doctor of law (*honoris causa*) on William Searle Holdsworth, K.C., D.C.L. (Oxford), Vinerian professor of English law in the University of Oxford, and the degree of doctor of science (*honoris causa*) on Sir Ernest Rutherford, O.M., M.A., of Trinity College, Cavendish professor of experimental physics, president of the Royal Society.

In introducing the recipients of the degrees the Public Orator, T. R. Glover, as reported in the London *Times*, said:

> That great man, the most illustrious of the Lord Chancellors of England, when caught at last by the cunning of his enemies, said he hoped there remained some quiet place for him in some Cambridge college where he might be at leisure for science. Accordingly, after three centuries, it is fitting for us Cambridge men to commemorate our great alumnus who has shed such honor on his Alma Mater by his name and his pursuits. Man, "the servant and interpreter of nature," lives by the laws of nature and by his own. The life of man, so long as we obey the laws of nature, flourishes. If, on the other hand, we try to live without human laws, nature refuses us her benefits. The Stoics, who teach us ever to strive to adjust our laws to the laws of nature, were filled with wonder for the inmost unity of the universe. Our Bacon was in his way the follower of the Stoics—eminent at once in civil law and natural science. So to-day we honor at once a man of law from Oxford and a student of nature from Cambridge, that it may be clear that all learning is linked with all learning, and that we serve

one nature while with one mind we pursue different studies. I present to you, then, that distinguished man, William Searle Holdsworth, Vinerian Professor of the Laws of England, Fellow of All Souls, not unacquainted with the other arts, and a famous oar. And I also present one whom you have long known—a high priest of natural science, censor of atoms, the flower of knighthood—our colleague and friend, Sir Ernest Rutherford.

About 1,500 invitations were issued for the garden party in Trinity College, and the guests were received by the master, Sir J. J. Thomson, and the vice-master, the Rev. Dr. St. John Parry, in the bowling green behind the Great Court. The band and pipers of the Scots Guards were in attendance and played a selection of music on the grounds of the college. The weather remained fine but dull, and the guests took advantage of the opportunity to visit the chapel, dining-hall and library of the college, the rare first editions of Bacon's works in the latter building being particularly interesting.

At 5.30 p. m., Dr. C. D. Broad, fellow of Trinity College, delivered a lecture in the Senate House on the philosophy of Francis Bacon before a distinguished company, presided over by the chancellor, Lord Balfour. The lecturer devoted his remarks to Bacon's claims to be the father of inductive philosophy.

THE PSYCHO-CLINIC FOR INFANCY RESEARCH AT YALE UNIVERSITY

THE Yale Psycho-Clinic for Infancy Research is to extend its program of psychological investigation and its clinical service for young children. The development of this work is made possible by a gift from the Laura Spelman Rockefeller Memorial. The staff of the Psycho-Clinic, which is under the direction of Dr. Arnold Gesell, has been enlarged by the appointment of several research associates, while the clinic itself is now housed in separate residential quarters at 52 Hillhouse Avenue. The clinic will devote itself for a period of years to the consecutive study of mental development in normal infants. The problems under investigation include the nature and origin of individual differences, correlations with physical characteristics, variations in rate of mental growth, norms and methods of developmental diagnosis in infancy. The program contemplates a coordination of several lines of research and combines a psychological and medical approach to the problems of infancy in their relation to human behavior.

The present staff has been organized for cooperative research into the first stages of mental growth, to determine their significance for later development. The research will concentrate on the first two years of infancy and bring into coordination data from different fields, including mental and physical measurements, language and motor capacity, habit and personality development. There are special laboratory provisions for technical photographic studies and for systematic camera records of mental and physical growth.

The new research appointees to the staff of the clinic are as follows: Henry Marc Halverson, Ph.D., research associate in experimental psychology and laboratory photography; Marian Cabot Putnam, M.D., research associate in developmental pediatrics, and Helen Thompson, Ph.D., research associate in statistics and anthropometry.

Professor Halverson was formerly head of the department of psychology at the University of Maine. Dr. Putnam is a graduate of the Johns Hopkins Medical School. She has served as pediatrist and neurologist at the Boston Children's Hospital and as assistant in psychiatry at the Phipps Clinic, under Dr. Adolph Meyer, of the Johns Hopkins University. Professor Thompson was formerly professor of mathematics at the Kentucky College for Women, also psychological research assistant at the Lincoln School, Teachers College, New York City. Katherine Backes, previously director of the Greenwich Nursery School, New York, and Anne K. Williams, R.N., will assist in the clinic.

The National Research Council has appointed two fellows to work in the clinic during the current year. They are Viola May Jones, M.A., assistant superintendent of the child placing department of the State Charities Aid Association of New York, and Edith Fisher Symmes, Ed.M., chief psychologist, Boston Psychopathic Hospital.

THE JOURNAL OF L. L. LANGSTROTH

IN 1852 the Reverend L. L. Langstroth, a Congregational minister in Philadelphia, devised a bee-hive with movable frames, the foundation of all modern beekeeping. The following year he published a book on beekeeping in which he described his new hive, and this has become a classic in beekeeping literature. In his many articles on beekeeping in various journals he makes frequent reference to a journal which he kept consistently for a period of forty-five years, but never did he tell just what material was included in it. After his death in 1893 all trace of this journal was lost and, in fact, none of the beekeepers of the present day had any definite knowledge regarding it.

The Ohio Beekeepers' Association at its meeting in August, 1925, decided that it was time that more recognition be given the man on whose labors so large an edifice has been erected, and at that time they established a memorial endowment fund in the Cornell University Beekeeping Library in memory of Mr.

Langstroth. The secretary of that organization, Miss Florence Naile, of Columbus, Ohio, had in the meantime become interested in the life and works of Mr. Langstroth and began a search for further information regarding him. She communicated with every living member of the Langstroth family and among other details she made inquiries regarding his journal, but was always told that it had been lost. By persistent effort she induced his family to make a more extended search for it, with the result that it was finally discovered in an attic in Dayton, Ohio, where he formerly lived.

The book is found to contain innumerable records of observations on the behavior of bees, of which only a small part was published by its author. It records in detail the steps through which his work passed in the invention of the modern bee-hive, and is, in fact, a detailed history of the early stages of the modern science of beekeeping. As has already been recorded in SCIENCE, at a meeting held by the Ohio Beekeepers' Association at Medina, Ohio, September 21 to 23, this journal was formally presented to the Beekeeping Library of Cornell University, where it will be carefully preserved and made available to future students of apiculture. It will form the corner-stone of the beekeeping library of the university, which is in large part a memorial to the man whose work has had such wide influence.

SCIENTIFIC NOTES AND NEWS

THE Pacific Division of the American Association for the Advancement of Science will hold its next annual meeting at Reno, Nev., from June 22 to 25, under the presidency of Professor William A. Noyes, of the California Institute.

THE John Fritz Gold Medal of the American societies of Civil, Mining and Metallurgical, Mechanical and Electrical Engineers for 1927 has been awarded to Elmer Ambrose Sperry, of New York, for the development of the gyro-compass and the application of the gyroscope to the stabilization of ships and aeroplanes. The presentation of the medal will take place at 8:30 on the evening of December 7, in the Engineering Auditorium, 29 West 39th Street, New York, in connection with the annual meeting of the American Society of Mechanical Engineers. At this session President William L. Abbott will deliver the annual address and Mr. Charles M. Schwab, president-elect, will be inaugurated. The medal will be presented by Dr. Frank B. Jewett, chairman of the board that made the award.

DR. ARTHUR H. COMPTON, professor of physics, University of Chicago, has been elected a member of the R. Accademia Nazionale dei Lincei at Rome.

ON his return from a summer spent on Mount Wilson, California, in measuring the speed of light, Professor A. A. Michelson, former head of the department of physics at the University of Chicago, announced that the Michelson-Morley experiment of 1883, upon the negative results of which Einstein based his theory of relativity, would be repeated on Mount Wilson next December.

THE American Mathematical Society has invited Dr. H. B. Williams, professor of physiology at the College of Physicians and Surgeons in Columbia University, to deliver the fourth Josiah Willard Gibbs Lecture. This lecture, entitled "Mathematics and the Biological Sciences," will be given at Philadelphia in connection with the approaching convocation week sessions of the American Association for the Advancement of Science.

DR. F. F. LUCAS, of the Bell Telephone Laboratories, has been awarded the medal of the Royal Photographic Society for his exhibit of high power photomicrographs of metallurgical specimens.

DR. CHARLES J. MARTIN, director of the Lister Institute and professor of experimental pathology in the University of London, and Sir Frederick Gowland Hopkins, professor of biochemistry in the University of Cambridge, have been appointed members of the British Medical Research Council into the vacancies caused, respectively, by the death of the late Lieutenant General Sir William Leishman, F.R.S., and by the retirement of Professor T. R. Elliott, F.R.S.

SIR FREDERICK KEEBLE, Sherardian professor of botany at the University of Oxford, has accepted an appointment with Synthetic Ammonia and Nitrates, Ltd., of Billingham-on-Tees, for the promotion of research in the application of synthetic nitrogen compounds to agricultural purposes.

DR. S. KARRER has resigned his position as chief of the physics division of the Fixed Nitrogen Research Laboratory in Washington, D. C., to become director of the Research Department of the Consolidated Gas, Electric Light and Power Co., of Baltimore.

DR. J. F. T. BERLINER, formerly of the Bureau of Chemistry of the Department of Agriculture, has been appointed to the staff of the Nonmetallic Minerals Station of the U. S. Bureau of Mines, New Brunswick, N. J., for research work on potash.

WALTER S. FROST, who for the past seven years has been assistant professor of chemistry at the University of New Hampshire, has joined the staff of Skinner, Sherman and Esselen, Inc., Boston, Mass.

DR. R. V. ALLISON, chemist and soil biologist for

the Tropical Research Foundation in Cuba, has been appointed soils specialist of the Everglades Substation of the Florida Experiment Station.

PROFESSOR W. M. DAVIS, of Harvard University, will spend October, November and December as a member of the faculty of the graduate school of the University of Texas. He will spend February, March, April and May in a similar position at the University of Arizona. The five weeks between these two engagements he will pass in California, where he will visit Pomona College and make an excursion, with Dr. Levi Noble, of the U. S. Geological Survey, to Death Valley. After leaving Tucson, Professor Davis will take part in the summer session of the University of California, at Berkeley, June 20 to July 30.

DR. BARTON WARREN EVERMANN, director of the museum and of the Steinhart aquarium of the California Academy of Sciences, is visiting eastern aquariums and museums. His itinerary includes Chicago, Detroit, Washington, New York, Philadelphia and other eastern cities. In addition to renewing acquaintances and studying methods, etc., in eastern institutions he proposes to devote some time to the study of the fishes collected by the academy on its recent expedition to the Revillagigedo Islands.

ELLSWORTH P. KILLIP, botanist of the National Herbarium of the Smithsonian Institution, assisted by Albert Smith, left on October 20 on a botanical expedition to Colombia. The expedition will disembark at Cartagena. It will work down the Magdalena River to Puerto Wilches, and then cross over to Bucaramanga and Pamplona near the Venezuelan border.

H. E. WHEELER, curator of the Alabama Museum of Natural History, has been selected by a group of Southern financiers to make a study of the museums of the North and East as a basis for developing those in the South.

DR. GEORGE B. CRESSEY has returned to Shanghai College from his third season's geological work in North China and Mongolia. Physiographic studies dealing with recent climatic changes were carried on in continuation of previous work. Unfortunately the expedition was attacked by brigands near the Great Wall and it was necessary to abandon further work.

DR. F. H. KNOWLTON, of the division of paleobotany of the U. S. National Museum, has completed three months' field work devoted to the paleontology and stratigraphy of various fossil plant areas in the United States.

DR. ALFRED P. DACHNOWSKI, of the Bureau of Plant Industry, U. S. Department of Agriculture, has returned from a study of European areas of peat. Dr. Dachnowski spent nearly five months abroad, traveling in Ireland, England, Sweden, Finland, Holland, Germany, Czechoslovakia, Austria and Italy.

DR. E. O. ULRICH, associate in paleontology of the U. S. Geological Survey, has completed two months' field work in a study of the Silurian and Devonian stratigraphy of Michigan in cooperation with the Geological Survey of that state.

DR. L. J. WEBER, instructor in metallography in the school of mines at the University of Minnesota, was employed during the summer by the American Body Company, of Buffalo, N. Y., to work on research in connection with the development of methods for welding high strength aluminum alloys such as those of aluminum, magnesium and silicon.

DIAMOND JENNESS, chief of the division of anthropology in the Victoria Memorial Museum, has just returned to Ottawa from a four months' field trip to Bering Strait, Alaska, where he was excavating some of the ancient Eskimo ruins and studying the local dialects in an effort to determine the origin and antiquity of an ancient Eskimo civilization.

DR. E. R. WAITE, director of the South Australian Museum, at Adelaide, is spending a sabbatical year traveling around the world visiting museums and museum workers. He recently spent some weeks at the American Museum of Natural History, New York City.

DR. WILLIAM M. DEVRIES, professor of pathology in the University of Amsterdam; Dr. R. Bierich, director of the Cancer Institute of Hamburg, Germany, and Dr. Archibald Leitch, director of the Cancer Hospital Research Institute, London, visited the Mayo Foundation during the week of October 3.

DR. FRIEDRICH BERGIUS and Professor Franz Fischer, of Germany, and General Georges Patart, of France, expect to attend the International Conference on Bituminous Coal which takes place from November 15 to 19, at the Carnegie Institute of Technology in Pittsburgh.

MME. MARIE CURIE, who has been invited to dedicate a scientific laboratory at St. Lawrence University, Canton, N. Y., will be unable to visit the United States this year. Mme. Curie, who recently returned from a series of lectures in Rio Janeiro, is now in Copenhagen, but will soon return to Paris. Her courses at the Curie Institute open on November 1.

PROFESSOR HERMANN WEIL, of the department of mathematics in the College of Technology, Zurich, gave two lectures on October 7 and 8 at Cornell University on the Goldwin Smith Foundation. Professor

Weil spoke on "Gravitation and Electricity," and "The Rôle of Infinity in Mathematics."

DR. ALEXANDER SAMOILOFF, professor of physiology at the University of Kasan, Russia, on September 30 gave a lecture at the opening meeting of the Physiological Conference at the Harvard Medical School, when he discussed "Characteristics of Spinal Reflex Inhibition."

DR. W. J. HUMPHREYS, of the U. S. Weather Bureau, gave an illustrated lecture on "Atmospheric Optics," at Rochester, N. Y., the evening of October 12, before the Rochester branch of the Optical Society of America.

COLONEL S. LYLE CUMMINS, David Davies professor of tuberculosis, Welsh National School of Medicine, and principal medical officer of the Welsh National Memorial Association, will give the Hermann M. Biggs memorial lecture at the New York Academy of Medicine on October 22. This lecture is given jointly under the auspices of the Medical Society of the County of New York and the New York Tuberculosis and Health Association.

AT a meeting of The Mayo Foundation chapter of Sigma Xi on October 11, Dr. Joel Stebbins, director of the observatory, University of Wisconsin, was the speaker of the evening. His subject was "The Light of the Stars."

DR. FRANZ LUDWIG FRIEDRICH ERNST PFAFF, formerly professor of pharmacology and therapeutics at the Medical School of Harvard University, died on September 26, aged sixty-six years.

DR. B. HARRY WARREN, formerly state ornithologist and state dairy and food commissioner, died on October 10, aged sixty-eight years.

DR. HENRY MILTON WHELPLEY, dean of the St. Louis College of Pharmacy and former secretary of the Missouri Pharmaceutical Association, has died at the age of sixty-five years.

THE death is reported from Bologna of Signor Francesco Piola, a professor of the Bologna School of Engineering and vice-president of the Bologna section of the Associazione Elettrotecnica Italiana.

DR. J. M. KING, professor of dermatology and electrotherapeutics in Vanderbilt University Medical School, died on October 12, aged fifty-nine years.

DR. CARLOS SPEGAZZINI, of La Plata, Argentina, the distinguished botanist, died on July 1.

THE next meetings of the Federation of American Societies for Experimental Biology will be held in Rochester, N. Y., on April 14, 15 and 16, 1927.

THE 141st regular meeting of the American Physical Society will be held in Chicago, at the Ryerson Physical Laboratory, on Friday and Saturday, November 26 and 27. Other meetings for the current season are as follows: 142. December 27–29, Philadelphia. Annual meeting. 143. February 26, New York. 144. Pacific Coast Section—place not yet determined. 145. April 22–23, Washington. 146. Pacific Coast Section—place not yet determined.

THE trustees and faculty of the School of Medicine and Dentistry of the University of Rochester have issued invitations to a scientific conference on October 25 and 26, which will mark the opening of the school. Dr. John C. Merriam, president of the Carnegie Institution, Washington, D. C., will address a public meeting; Dr. Ludvig Hektoen, Rush Medical College, Chicago, will read a paper on "Recent Investigations in Scarlet Fever, Measles and Tuberculosis"; Dr. Joseph Erlanger, St. Louis, "Analysis of the Action Current of the Nerve," and Professor Friedrich Müller, Munich, will speak in the evening on "The General Pathology of Joint Diseases"; Dr. Theobald Smith, on Tuesday morning, will read a paper on "Immunity, Natural and Acquired, as illustrated by Experiments with Bacillus Coli and its Mutants," and Dr. Lewis H. Weed, Baltimore, a paper on the "Problem of the Relation of the Muscle and Nerve." Professor Müller will conduct a medical clinic on Tuesday evening and Dr. Harvey Cushing, Harvard Medical School, Boston, a surgical clinic.

THE thirteenth annual meeting of the New England Agronomists will be held on December 3 and 4 at the Boston City Club. The program will open with a banquet on Friday evening, December 3, after which Dr. E. B. Wilson, chief of the Harvard bureau of vital statistics, will address the agronomists on "Statistical Methods." This address will be followed by a round table discussion. The program on Saturday, December 4, will center around the topic of "Crop Succession," with papers by various members. The annual business meeting and election of officers will be held before the close of the meeting.

THE fifth annual meeting of the American College of Physical Therapy is being held at the Drake Hotel, Chicago, from October 18 to 23, under the presidency of Dr. John S. Coulter, Chicago, and in conjunction with this meeting there will be a Clinical Congress of Physical Therapy.

THE next meeting of the board of National Research Fellowships in the Biological Sciences, of which Professor Frank R. Lillie is chairman, is planned for about the first week in February. The exact date will be published later. Applications for

consideration at this meeting should be received by the secretary, at the National Research Council building, B and 21st Streets, N. W., Washington, D. C., by January 1, but may be sent in at any time prior to that date. This meeting is to care for those persons who can not very well await a decision of the board on their applications until the spring meeting. It is proposed that the second meeting for the year be held about May. Definite information on this will be announced after the February meeting.

DR. ROY CHAPMAN ANDREWS, head of the Central Asiatic Expedition of the American Museum of Natural History, arrived in New York on October 6. Dr. Andrews has been invited by the Royal Geographical Society of London to deliver the opening address before the society on November 8. He will leave New York for England about October 25, and will make a formal presentation of the expedition's geographical results to the society. He also will address the Central Asian Society in London on November 10. Returning to New York, about November 20, Dr. Andrews will spend the winter in America lecturing and will leave for China about March 1, 1927. Members of the expedition who have returned to America or are on their way back are: J. B. Shackelford, photographer; Dr. Mont Reid, surgeon, and Dr. W. D. Matthew, paleontologist. Other members have remained in China to carry on field work. They are: Walter Granger, chief paleontologist, and Nels Nelson, archeologist, who are making a reconnaissance in Southwest China in Yun-nan Province; Clifford Pope, who is collecting fish, reptiles and mammals in Fukien Province; George Olsen, assistant in paleontology, who will collect fossils in Szechwan Province; McKenzie Young, chief of motor transport, who remains in Pekin to buy and pack supplies of food and gasoline and start a new caravan into the desert by February 1. He will make a search for the caravan that has disappeared as soon as it is possible to do so.

COLUMBIA UNIVERSITY has announced gifts amounting to $155,358. These include $18,000 from the Borden Company for research in food chemistry and nutrition; $15,000 from the Commonwealth Fund for the psychiatric clinic fund; $5,000 from the Walker Gordon Laboratory Co. for research in food chemistry and nutrition; $2,000 from Eli Lilley and Co. for the pernicious anemia fund in the department of pathology; $1,800 from Mrs. Elsie Clews Parsons for research work in the department of anthropology; $1,500 from Homer Sargent for research work in the department of anthropology, and $750 from the E. I. du Pont de Nemours and Company for the maintenance of a fellowship in industrial chemistry.

THE TROPICAL PLANT RESEARCH FOUNDATION has undertaken for the wood industries division of the American Society of Mechanical Engineers a preliminary research on tropical woods, with special reference to their uses in domestic industries, as substitutes for species of native woods now scarce, or, by reason of approaching exhaustion, of poor quality and unsuitable for the finer products. Major George P. Ahren, of the board of trustees, and Mr. Donald M. Matthews, forester of the foundation, are summarizing the present state of our knowledge of tropical hardwoods and preparing a program of constructive work for the future.

ACCORDING to an announcement by Dr. H. A. Gleason, a curator of the garden, a large number of botanical species hitherto unknown to science have been discovered in classifying a collection of nearly 30,000 plants which the New York Botanical Garden has received from British Guiana. Most of the collection, which outrivals any in Europe except that of the Royal Botanic Garden at Kew, was made and sent to Dr. Gleason by an unlettered Indian, La Cruz, after Dr. Gleason had returned to this country from a trip to British Guiana in 1921.

UNIVERSITY AND EDUCATIONAL NOTES

PRESIDENT MAX MASON, of the University of Chicago, reports that the total gifts to the credit of the development fund amount to $9,253,654. Since June 10, 1926, when the last report was made to the board of trustees, a total of $243,177 has been pledged.

BY the will of the late Mrs. Mary E. Larkin Joline, Barnard College receives the sum of $110,000. A share, which is expected to amount to about $100,000, of the residuary estate, is left to Princeton University.

THE cornerstone of the new $300,000 Charles Rebstock Hall of Biology at Washington University was laid by the donor on October 13.

DR. JOHN H. MACCRACKEN has retired as president of Lafayette College, after serving for eleven years. Donald B. Prentice, dean of the School of Engineering, has been appointed acting president.

EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research, University of Pittsburgh, has announced the appointment of Dr. George Denton Beal, of the University of Illinois, to an assistant directorship of the institute.

DR. A. C. HEILAND, who for the past two years has been connected with Askania Verke, manufacturers of geophysical instruments in Berlin, has been appointed professor and head of the newly established department of geophysics at the Colorado School of

Mines. This is said to be the first time that a course in geophysics has been introduced into an American college or university.

ASSISTANT PROFESSOR F. W. OWENS, of Cornell University, has been appointed head of the department of mathematics at Pennsylvania State College.

DR. A. F. O. GERMANN has resigned his position with the Laboratory Products Company, where he was in charge of development and research, in order to organize work in chemistry at Valparaiso University, Indiana.

PROFESSOR A. C. SEWARD, master of Downing College and professor of botany in the University of Cambridge, has relinquished the office of vice-chancellor of the university which he has held for the past two years. He is succeeded by the Rev. George Arthur Weeks, master of Sidney Sussex College.

DR. J. H. SIMONS, head of the department of chemistry at the University of Porto Rico, has joined the staff of Northwestern University, where he will continue his researches in physical chemistry.

ERNEST CLARE BOWER, associate astronomer at the U. S. Naval Observatory, has been appointed assistant professor of astronomy and mathematics in Ohio Wesleyan University.

DR. S. B. CHANDLER, of Northwestern University, and Dr. Gordon H. Scott, of the University of Minnesota, have been appointed to assistant professorships in anatomy in Loyola University School of Medicine, Chicago.

DISCUSSION AND CORRESPONDENCE

THE USE OF PITH DUST IN A KUNDT'S TUBE

DURING the summer of 1924, while experimenting at Indiana University with a Kundt's tube, I discovered that the striae could be most readily observed by using pith dust in the tube.

I obtained the pith dust by grinding dry pith from sunflower on a fine-grained emery wheel. By the use of this dust I was able to obtain discs that extended completely across the tube and having the same diameter as the inside of the tube.

These striae were obtained by the ordinary method used with a Kundt's tube, but for demonstration purposes I found the following to be an excellent way to produce them: Some pith dust was placed in a glass tube of any convenient length and diameter. In one end of the tube a stopper was placed and the open end of the tube was inserted in the open end of a sounding organ pipe. When the tube was inserted the proper distance the striae formed at regularly spaced intervals and showed the nodes and loops in an excellent way. Discs apparently but one particle in thickness were formed and when the tube was carefully adjusted with regard to distance to which it was inserted into the organ pipe the separate particles remained almost motionless. Often they wove themselves into thin sheets and when the air was turned off they fell over, maintaining the sheet form.

Also I obtained these striae by passing an electric spark across the end of a glass tube (either open or closed) into which some pith dust had been placed. The howl produced by a telephone receiver excited excellent striae in a glass tube. Some photographs of the striae were made.

Pith dust being lighter than cork dust gives striae of greater height than the latter. As it does not adhere to the tube I find its use for this purpose better than lycopodium powder.

ROLLA V. COOK
BETHANY COLLEGE

TWO INTRODUCED PLANTS OF RARE OCCURRENCE IN THE UNITED STATES

Two plants of very rare occurrence in the United States have come to the writer's attention in this section in the last few years and it seems worth while to broadcast the news for interested botanists.

Two specimens of *Tagetes minuta*, L., were found in a field of Rhodes grass in Riverside, California, in 1921. Thinking them to be marigolds the rancher transplanted them by his house, where they grew to be ten and eleven feet high with a spread of five to six feet. They were identified by Miss Alice Eastwood, of the California Academy of Sciences, and the Smithsonian Institution later reported that the plant had been reported only once before in this country, from North Carolina—probably having been introduced upon ballast in some boat. The Rhodes grass seed used for planting the field in which the plants were found at Riverside was imported from Australia.

Three plants of an unrecognized *Erodium* were found in the cover crop of a lemon orchard at Corona, California, on February 26, 1923. Purple vetch had been sown as a cover crop, the seed doubtless coming from Washington or Oregon, but its germination was very poor and the majority of the cover crop growth was made up of our common *Erodium cicutarium*.

Only a flower specimen of the plant was saved in 1923. Owing to a very dry winter there was practically no cover crop growth in this orchard in 1924, but in 1925 about twenty plants of the new *Erodium* were found and it was identified by Miss Alice Eastwood, of the California Academy of Sciences, and by Dr. I. M. Johnston, at the Gray Herbarium, as *E.*

cygnonum, Nees., a native of Australia and New Zealand. This species was reported only twice previously on March 18, 1917, near San Diego, California, and on September 5, 1917, on a wool-waste dump at North Chelmsford, Massachusetts.

An interesting observation regarding the blooming of this species was that while the flowers of *E. cicutarium* were withered and fallen by eight or eight-thirty o'clock on bright mornings, the flowers of *E. cygnonum* were only half opened at that time and they persisted till about one o'clock in full sunshine.

C. S. POMEROY

U. S. DEPARTMENT OF AGRICULTURE,
RIVERSIDE, CALIFORNIA

PROTECTION OF THE TUMION IN FLORIDA

OUR national monuments should be protected before it is too late. Lack of a state forestry policy and the rapid disappearance of so much natural beauty in many states are already causing much alarm. Beautiful sights along lakes and mountains are denuded, and our immense forests are destroyed for the lumber trade, without any attempt to renew them on a technical basis. These facts are known throughout the world. Quite recently the Count of Schwerin and Freiherr von Thielmann, both in Berlin, have drawn attention to this fact to foresters and scientists in European countries. They stressed the disappearance of the beautiful forests in the United States.

It becomes of international importance when certain forest species become extinct. Such a forest is found along the bluffs on the east bank of the Apalachicola River from Chattahoochee to Bristol in the northwestern part of Florida. Along a distance of hardly seven miles we find some extremely rare trees, namely, *Tumion taxifolium* Greene and *Taxus floridana* Chapm. Both are coniferous trees; the former reaches a height of 30 to 40 feet and the latter becomes rarely 25 feet high. No doubt both are relicts of ages long past, when a considerable part of the country was covered with these and perhaps other related species.

When the glacial periods came over a large portion of this country and over Europe and Asia, the geographical distribution of these plants was gradually pushed back to some protected and favorable areas along the Apalachicola River. These rare trees are generally used in this region as Christmas trees, thus hastening their disappearance in their natural environment.

I urgently ask those who are interested in the rare forest flora of that small area along the Apalachicola River to have this region protected as a national park. It will be of great benefit to science to have this place as a natural monument that will be cared for throughout the ages. If no immediate steps are taken but a very few years will elapse before that section will be completely denuded of all its natural beauty.

The United States, when we consider its large area, is not too rich in protected natural monuments nor in national parks. Its forest destruction goes on day by day without proper management. We could not do better than to repeat the words of Baron Ferdinand von Müller: "I regard the forest as a heritage given to us by nature, not for spoil or to devastate, but to be wisely used, reverently honored and carefully maintained."

J. C. TH. UPHOF

ORLANDO, FLORIDA

POLEMONIUM SEEDS

DURING some years I have been engaged in genetical work on the genus *Polemonium* (Polemoniacea) which seems well fitted for studies of that kind. By means of the seed catalogues of the Botanical Gardens of the northern hemisphere I have got numerous collections of seeds supposed to represent a rather large number of species, but growing experiments showed that under the many names really only few species were present, the identifications in many cases being erroneous.

As most of the species occur in North America it is difficult for a European botanist to get seeds from wild-growing specimens, and therefore, I ask American botanists to help me by collecting seeds of species which they may come across and send them to me. I shall be very grateful for such assistance.

C. H. OSTENFELD

BOTANICAL GARDENS,
COPENHAGEN, DENMARK

SCIENTIFIC BOOKS

Elements of Astronomy. By E. A. FATH. VIII + 307 pp., 191 figures. McGraw-Hill Book Co., N. Y. Price, $3.00. 1926.

> And still they gazed and still their wonder grew,
> That one small head could carry all he knew.

THE reader of Professor Fath's "Elements of Astronomy" is left in much the same frame of mind as were the rustics of the "Deserted Village" after contemplating their schoolmaster. In a book of slightly less than three hundred pages of text we find the elements of practically everything that had been accomplished in astronomy up to the end of 1925. The book should receive a hearty welcome from teach-

ers of astronomy and readers who desire a "non-mathematical treatment of the science of the stars."

The subject-matter of the book is very comprehensive and all fields of astronomy are touched upon. In general the author has preserved a good sense of balance and proportion and has not overemphasized certain fields at the expense of others. In the attempt to preserve the non-mathematical character of the book we find the descriptive method of presentation employed rather than the analytical. For the same reason, and also for the sake of brevity, the style of the text is rather dogmatic and in many cases simple proofs of statements are omitted.

The various controversial points in astronomy are well handled. All sides of the various questions are presented, in so far as space will permit, and the reader is left to draw his own conclusions from the material presented. In some cases Professor Fath does indicate the conclusions which he or others have reached, but he does not attempt to force these opinions upon the reader.

The physical make-up of the book itself is excellent. The binding is substantial and the paper of a quality capable of taking a good impression from the type and cuts, and also capable of withstanding the rough handling of the undergraduate. The type is clear and legible and the numerous cuts are admirably executed. Furthermore, the text is remarkably free from the annoyances of typographical errors which so frequently mar first editions.

After so much praise, a few words of criticism may not be out of place. In the attempt to avoid too lengthy a treatment for a first course some material has been omitted which will seem to many teachers as very important. The fields of spherical and practical astronomy have suffered the most severely. For example: the chapter on the celestial sphere, while it does contain all important definitions expressed very clearly, does not contain any reference to the simple methods for converting from one system of coordinates to another. The same criticism may also be applied to the excessively brief section on time. It also seems unfortunate that the fundamental problems of practical astronomy concerned with navigation should be merely mentioned in the introductory chapter and that no mention should be made of that important instrument, the sextant. Throughout the text dates are given and reference made to original discoverers, but little or no attempt is made to show the tremendous influence of astronomical discoveries on the history of civilization or upon the other sciences. Such material might well be substituted for the weak sections upon such subjects as the theory of relativity and atomic theory.

WARREN K. GREEN
AMHERST COLLEGE OBSERVATORY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE CULTIVATION OF ENDAMOEBA HISTOLYTICA

IN an endeavor to simplify the culture medium of Boeck and Drbohlav[1] for the cultivation of *Endamoeba histolytica,* the cause of amoebic dysentery, which has proven so successful for that purpose, the following culture medium has been found even more successful, in that the amoebae live for a longer period of time in it and grow to a much greater size. It is a fluid medium, unlike all other media that have been proposed for the purpose, and possesses the advantages of markedly inhibiting bacterial growth, simplicity of preparation, and greatly facilitating researches on the effect of chemical agents upon the amoebae.

As used in this laboratory the medium is prepared as follows. The Locke solution used has the following formula:

Sodium chloride	9.00 gm.
Calcium chloride	0.24 gm.
Potassium chloride	0.42 gm.
Sodium bicarbonate	0.20 gm.
Dextrose	2.50 gm.
Distilled water	1000 cc.

This solution is filtered and autoclaved at fifteen pounds pressure for fifteen minutes, and allowed to cool. To it is then added one part of inactivated human, horse or rabbit blood serum to each seven parts of the Locke solution used. After adding the blood serum the whole is thoroughly shaken and filtered through a Mandler or Berkefeld filter. Sometimes it is necessary to filter through two or more candles before the filtrate is perfectly clear. After filtration the medium is tubed, placing 5 cc in each suitably sized test-tube, and incubated for twenty-four hours at 37° C. If found sterile the tubes should be kept in an incubator at 37° C. until used. The reaction of the medium does not need adjusting, as it is always favorable for the growth of the amoebae when first prepared. Inactivation of the blood serum is necessary and we have found that human blood serum gives the best results, with horse and rabbit serum followed in the order named.

The medium is inoculated by placing a loopful of the feces to be examined in the medium and breaking it up thoroughly with the inoculating loop. After inoculation the tubes are placed in an incubator at 37° C. for twenty-four hours and a small portion of the sediment at the bottom of the tube examined at the end of that time. The amoebae will always be found in the sediment, and usually occur in

[1] Boeck, W. C., and Drbohlav (1925), *Am. Jour. Hyg.,* V. 371.

large numbers in this medium if present in the feces. Transfers are made by removing a small portion of the sediment and transferring it to an uninoculated tube which should have been kept in the incubator at 37° C. Transfers are most successful if made every twenty-four or forty-eight hours, but successful transfers have been secured from an eight-day old culture, and motile amoebae have been found in cultures as old as eleven days. Transfers in this medium have been carried on in this laboratory for over two months and apparently may be continued indefinitely.

The excellent growth and reproduction of *Endamoeba histolytica* in this medium composed entirely of Locke's solution, slightly modified, and human, horse or rabbit inactivated blood serum, demonstrates that media containing a solid substratum containing egg albumen or blood is not essential for the cultivation of this species and that neither egg albumin nor blood is necessary as a part of the food supply of this amoeba, as stated by Kofoid and Wagener.[2] A more detailed description of our experience in the cultivation of *Endamoeba histolytica* in this medium, together with some account of the morphology and biology of the organism as observed under cultivation, will be published in the September number of the *American Journal of Tropical Medicine.*

CHARLES F. CRAIG

ARMY MEDICAL SCHOOL,
WASHINGTON, D. C.

A RAPID METHOD FOR PREPARING THIN SECTIONS OF UNDECALCIFIED BONE

THE usual method of grinding slabs of bone between hones in order to prepare sections thin enough for microscopic examination is very laborious and requires more time than many workers are willing to devote to it. Equally satisfactory sections can be prepared with a great deal less labor and in a much shorter time by using files. It is possible to saw off and grind a radial slab 5 cm long or half of a transverse slab of ox femur within an hour.

Thin slabs of bone should be secured by sawing. Clamp a suitable piece of bone in a vice so that it projects 2 mm or 2.5 mm beyond the jaws. Avoid gripping it too tightly lest excessive strain cause microscopic cracks which will result in the section breaking up as it is ground thin. The jaws of the vice should be protected by straight-edged strips of metal to prevent damage by the saw. Saw off the slab with a hack saw, using the parallel edges of the metal guards as guides in order to secure a slab with parallel surfaces. With reasonable care a smooth slab about a millimeter in thickness should result. Rub one surface of the slab on a twelve or fourteen inch flat mill file to remove any roughness due to the sawing. Attach the partially smoothed surface to the metal face of an old half-tone plate of suitable dimensions. This can be done by heating the plate in a flame and rubbing a piece of hard paraffin over it, then pressing the slab of bone into the molten paraffin. It is best to press it in by holding some object with a flat surface against it in order to insure uniform pressure over the entire area. Chill the paraffin while the slab is still under pressure by dashing cold water over it. Trim away any excess of wax and rub the slab on the file, using the half-tone plate as a holder. When a perfectly plane surface has been produced, polish it by rubbing for a few minutes on a flat hone. A hone that has been rendered concave by sharpening microtome knives is useless until it has been resurfaced. Very critical workers may wish to impart an additional polish by rubbing on a glass plate with optician's polishing powder. Reverse the slab on the plate and rub the other surface on the file until it is thin enough over its entire area to permit of seeing the etching on the plate beneath it. Polish the second surface in the same manner as the first. Loosen the section with xylol and transfer to a dish of xylol to remove the wax. If dust adheres, transfer successively to alcohol and water and wash carefully with soap. If it be desired to entrap air in the spaces between the bone cells, allow the section to dry and mount directly in melted balsam. If fully cleared sections be desired, dehydrate, clear and mount in the usual manner. If several mounts are to be made from one section, fine scissors should be used.

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[2] Kofoid, C. A., and Wagener (1925), Univ. Cal. Pub. Zool., XXVIII, 136.

SPECIAL ARTICLES

NOTE ON ARTERIOSCLEROSIS IN RABBITS CAUSED BY SOME SAMPLES OF URANIUM NITRATE[1]

IN the course of some experiments that were being made to find whether or not the renal atrophy produced by uranium nitrate was accompanied by elevation of the blood pressure, there was found at autopsy in three rabbits which died in succession a severe arteriosclerosis of the aorta and of the peripheral vessels. In one animal the aorta appeared from the outside not unlike the trachea, this ring-like appearance extending into the carotids, subclavians, renals and iliacs, and even into the thyroid and para-

[1] From the H. K. Cushing Laboratory of Experimental Medicine, Western Reserve University, Cleveland, Ohio.